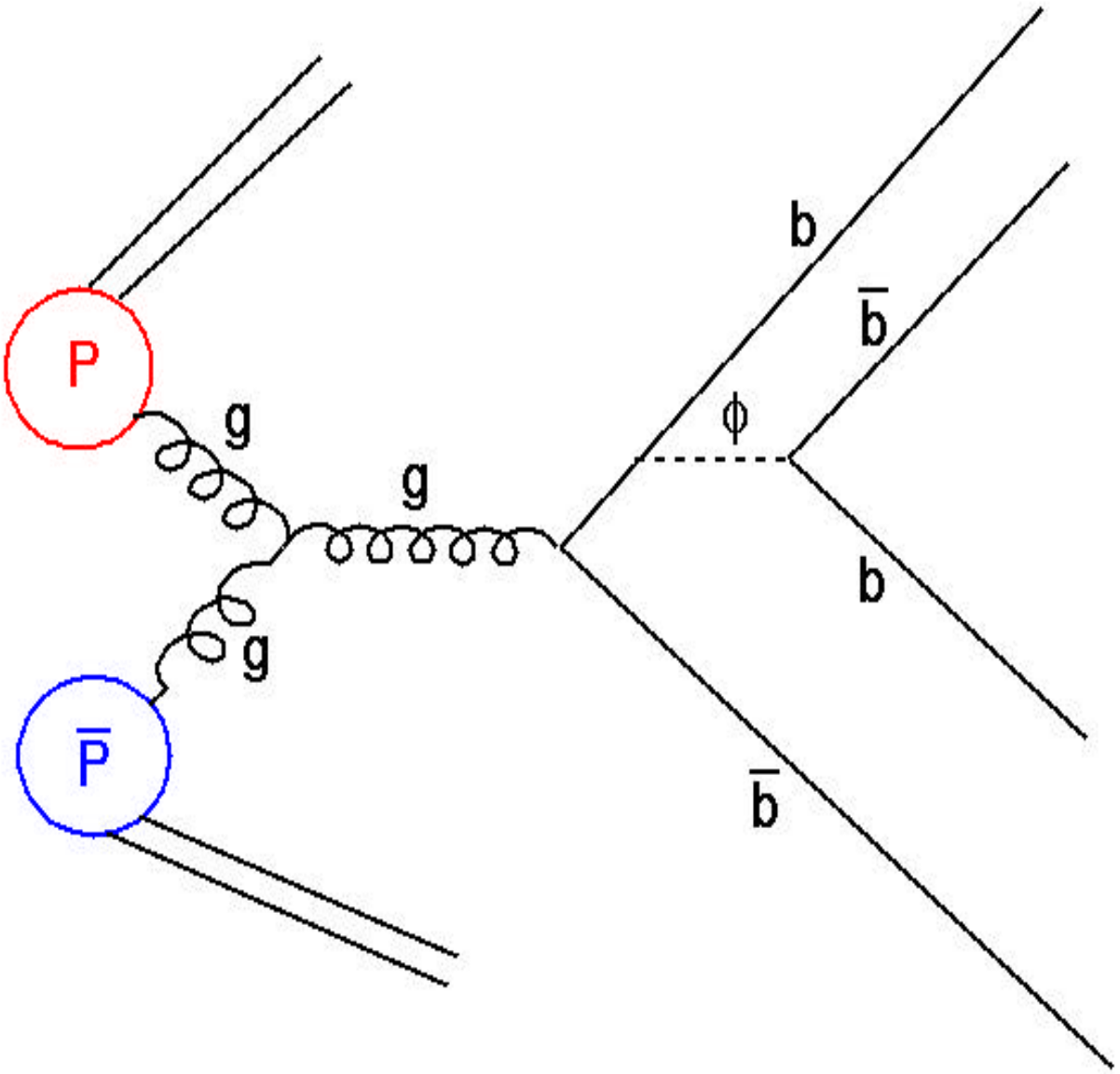
Study of b-jet tagging using bbh(→bb) and ddh(→dd) samples

K. Jyothsna Rani

Department of High Energy Physics

In a Nutshell



Outline

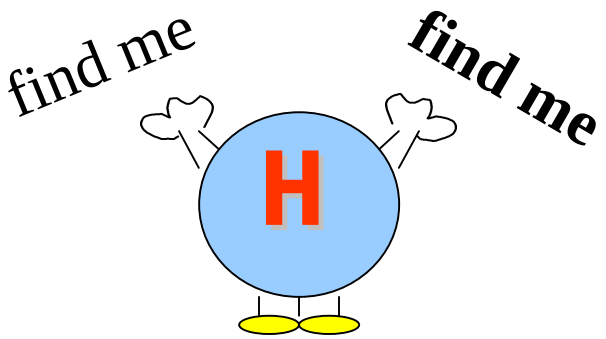
- Introduction
- Higgs Production Mechanism and Decay
- Simulation Framework at Dzero
- b – quark properties
- Identifying jets formed by b – quarks
- Event Kinematics
- Secondary Vertex Tagging studies
- Conclusions

Introduction

- Tevatron at Fermilab is the world's highest energy accelerator.
- At Tevatron proton and antiproton are accelerated to 1 TeV.
- Proton and antiprotons are collided at CM energy $\sqrt{s}$ = 2 TeV at two detectors CDF and Dzero.

DZero Detector

Dzero is a collider detector at Fermilab.



Bit of Theory

- Higgs is the missing piece in Standard Model.
- SM Higgs mass is unstable against quantum fluctuations.
- One of the solutions to the above is to go for Minimal Supersymmetric extension of Standard Model (MSSM).

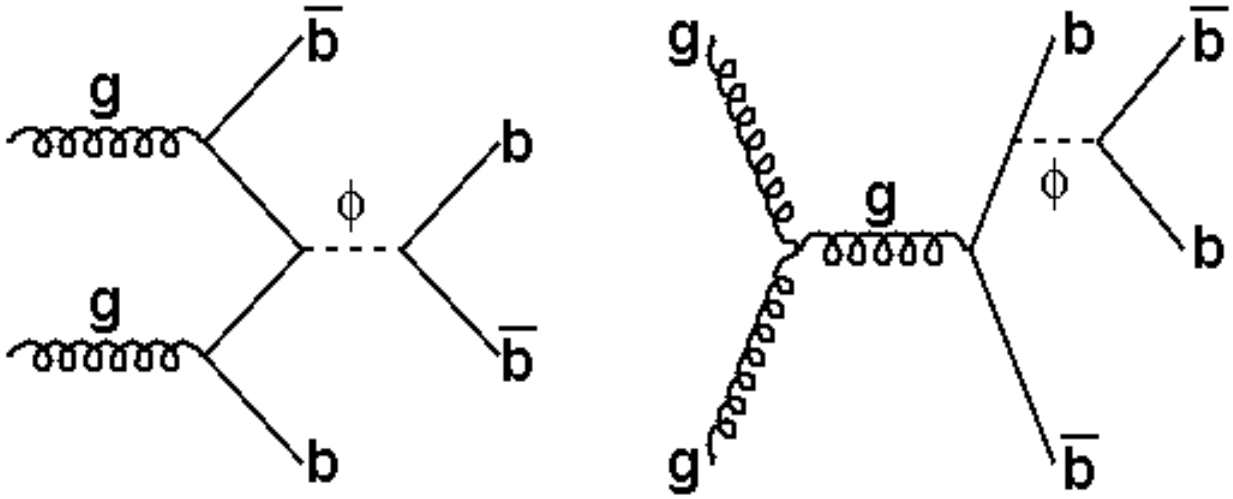
Higgs in MSSM

- Minimal Supersymmetric Standard Model is
  - SM
  - An extra Higgs doublet
  - Supersymmetric partners
- Five physical Higgs bosons h, H, A, $H^{\pm}$
- Two free parameters in this theory are m_A and tanβ where tanβ is ratio of vacuum expectation values of two Higgs doublets.

Why MSSM 4b is preferred compared to SM 4b channel?

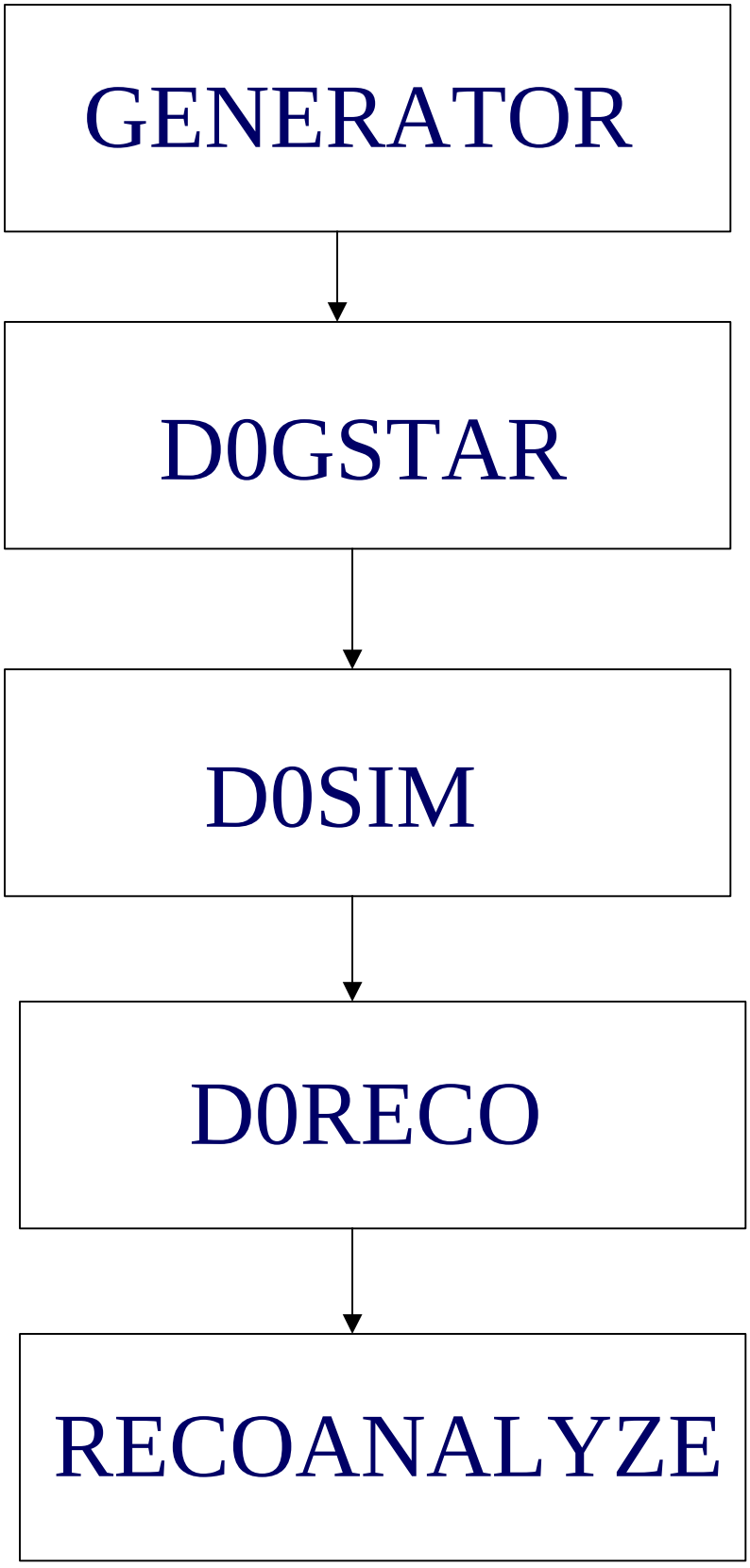
- In SM Higgs boson coupling to b quark is rather weak $\sim m_b/v$ (v=246 GeV)
- In MSSM the b-quark coupling to Higgs boson is enhanced by ~ tanβ
- Thus φbb associated production cross-section is expected to be large.

Production Mechanism at Tevatron



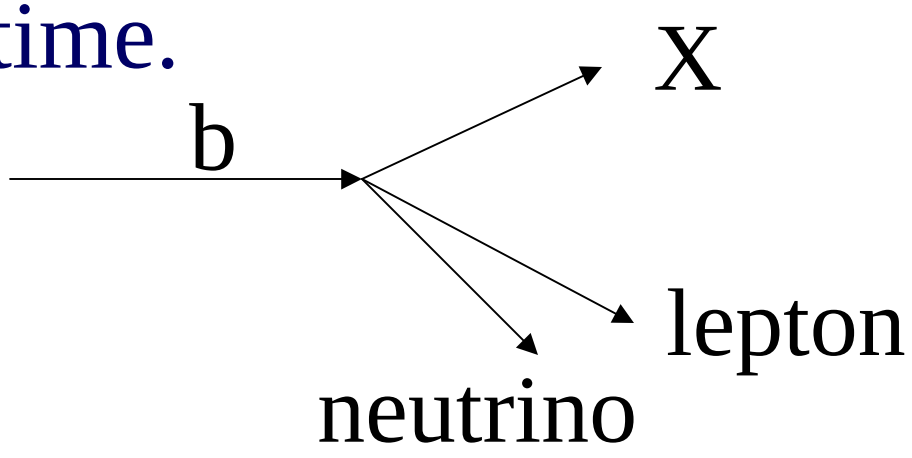
These are leading order Feynman diagrams for neutral Higgs production at Tevatron.

Simulation Framework

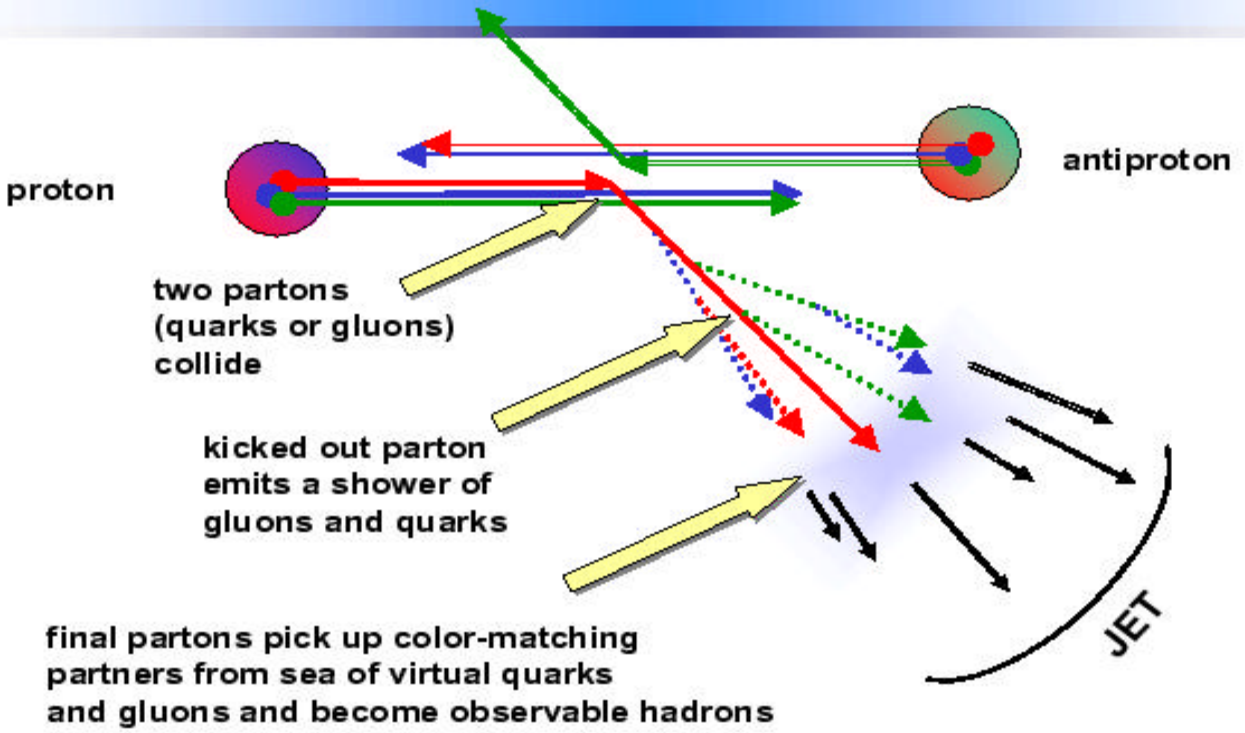


b – quark properties

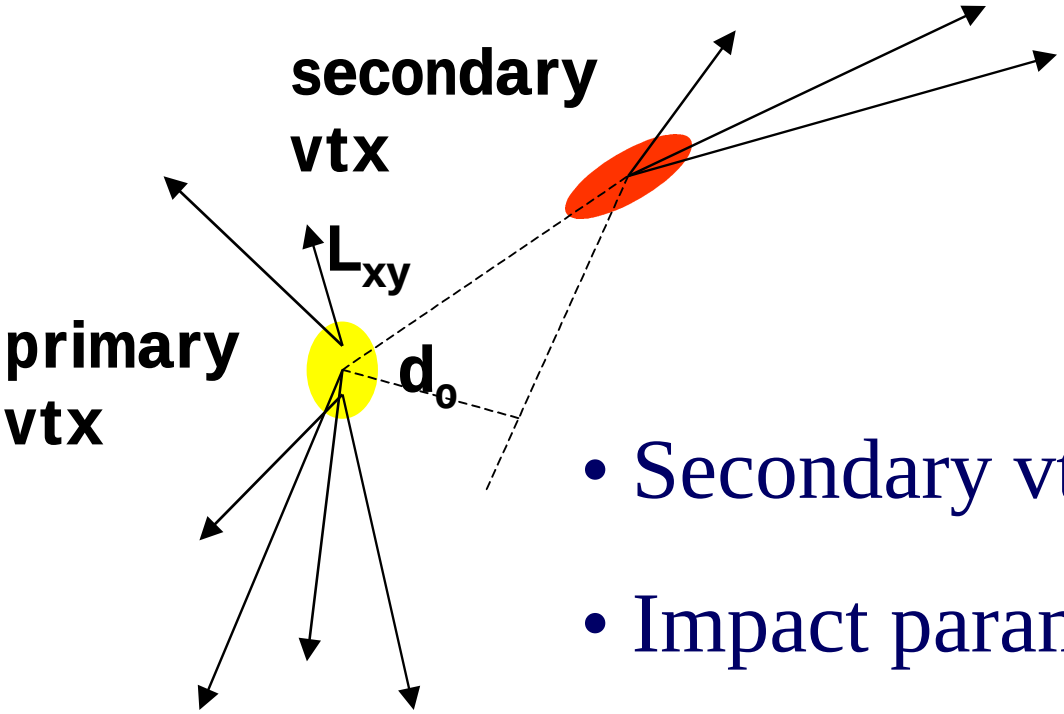
- b – quarks fragment and give B hadrons (b – jets).
- B hadrons have long lifetime $<c\tau> \sim 450\ \mu m$.
  - Secondary Vertex
  - Impact parameters of the decay products
- b – quark decays semi-leptonically 20% of the time.



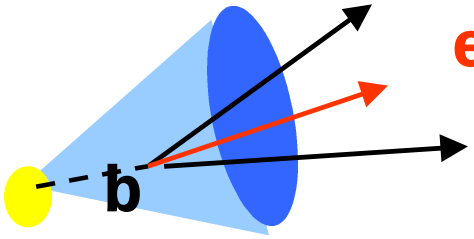
Formation of jets in three steps



Identifying b-jets



- Secondary vtx
- Impact parameter



e or μ in jet

- Soft Lepton tagging

Event Kinematics(1)

- MC samples used are bbh(→bb) 5000 events for b-tagging performance and ddh(→dd) for mistag rate estimation.
- Input Higgs Mass =120 GeV
- tanβ = 1 and R(cone)=0.5
- No pile-up of min. bias events superimposed.

Event Kinematics(2)

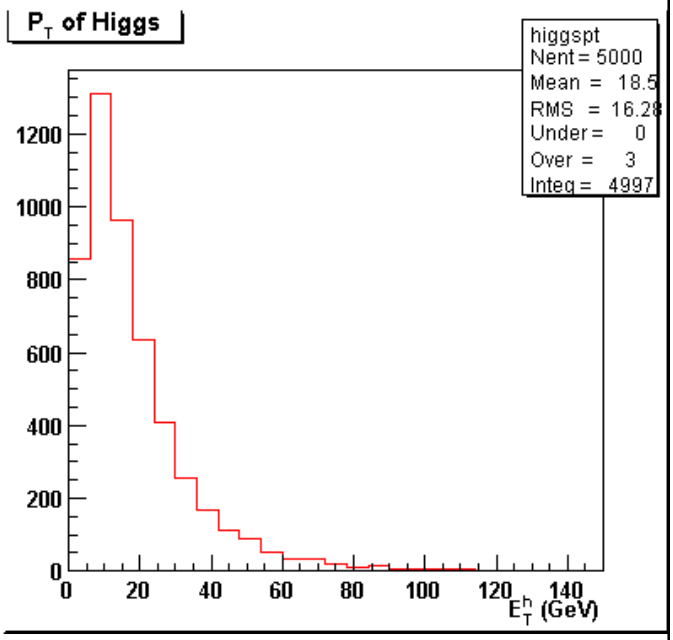
Transverse momentum $P_T = P \sin\theta$

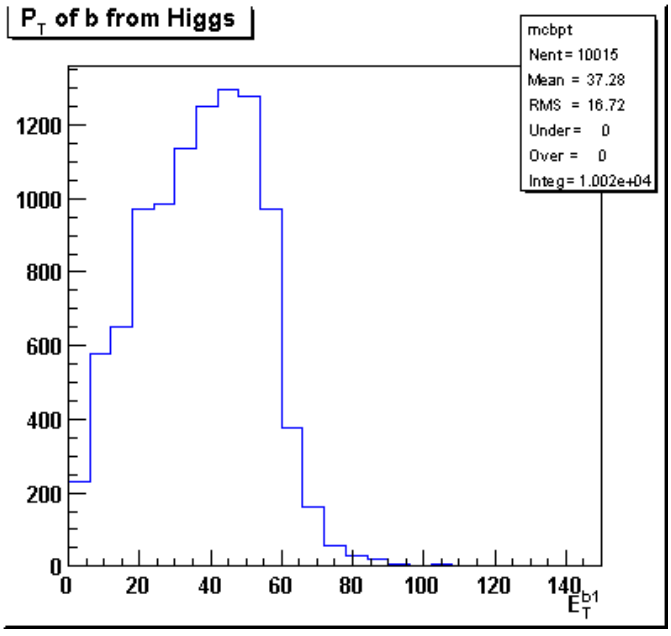
θ is the polar angle.

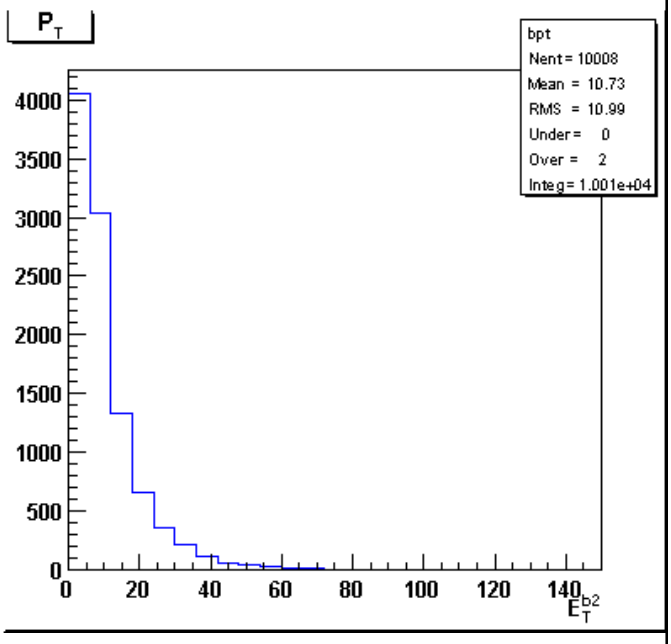
P_T distributions for

- Higgs
- b's from Higgs
- Associated b's

at generator level.







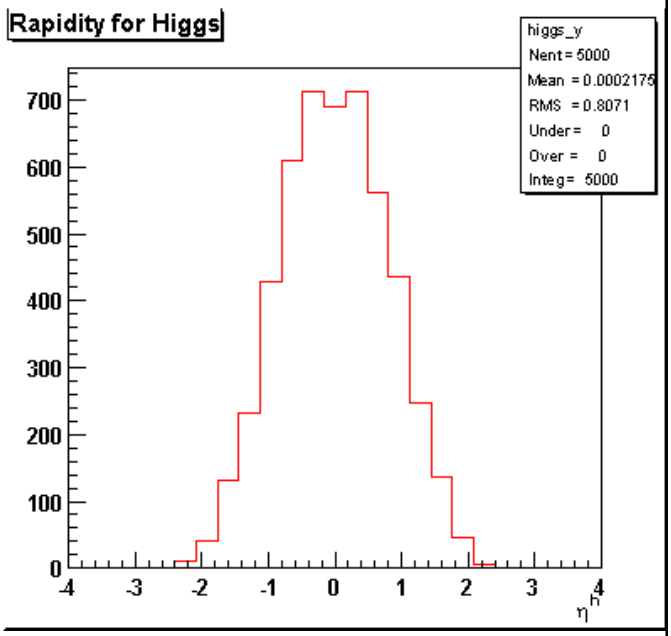
Event Kinematics(3)

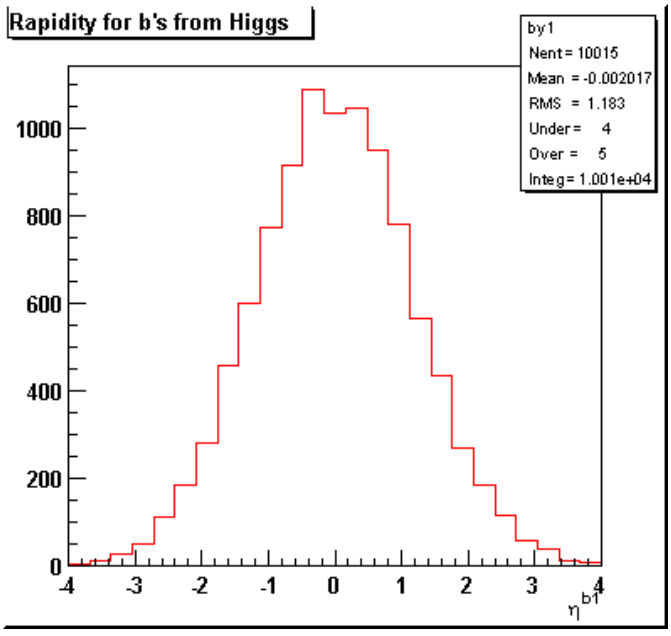
Pseudorapidity $\eta = -\ln \tan(\theta/2)$

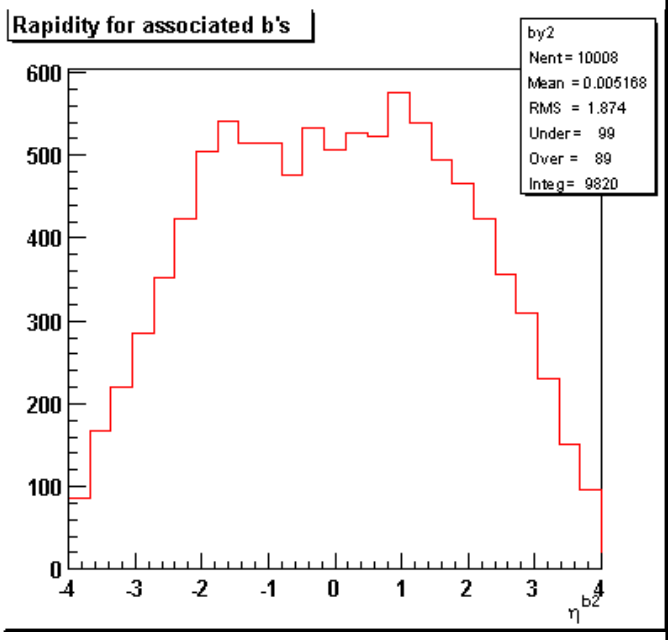
η distributions for

- Higgs
- b's from Higgs
- Associated b's

at generator level.



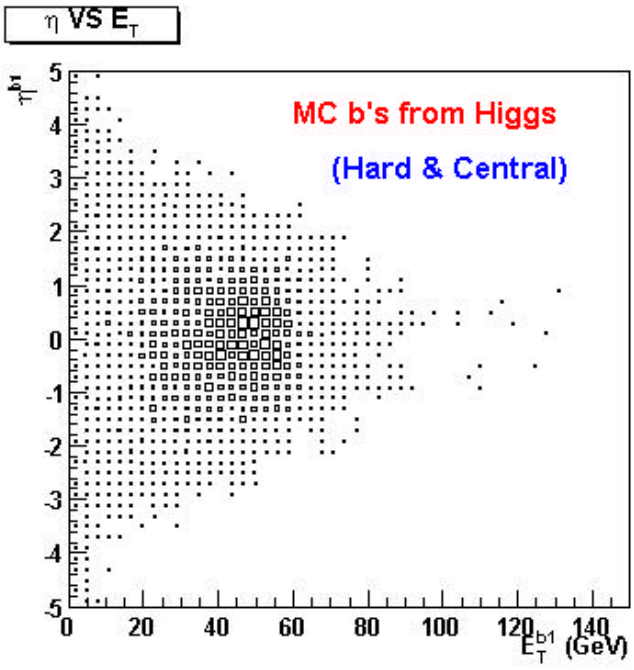


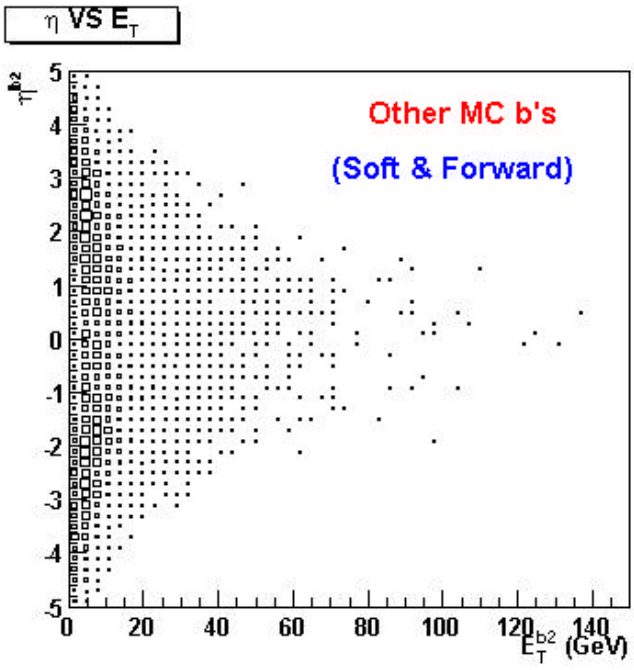


Event Kinematics(4)

At the generator level

η vs P_T correlations for MC b quarks





b's from Higgs are hard and central

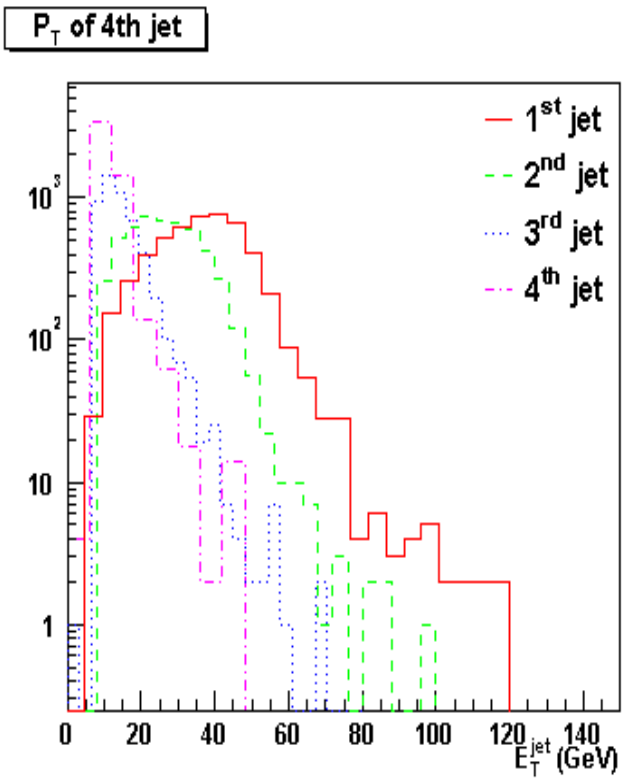
Associated b's are soft and forward

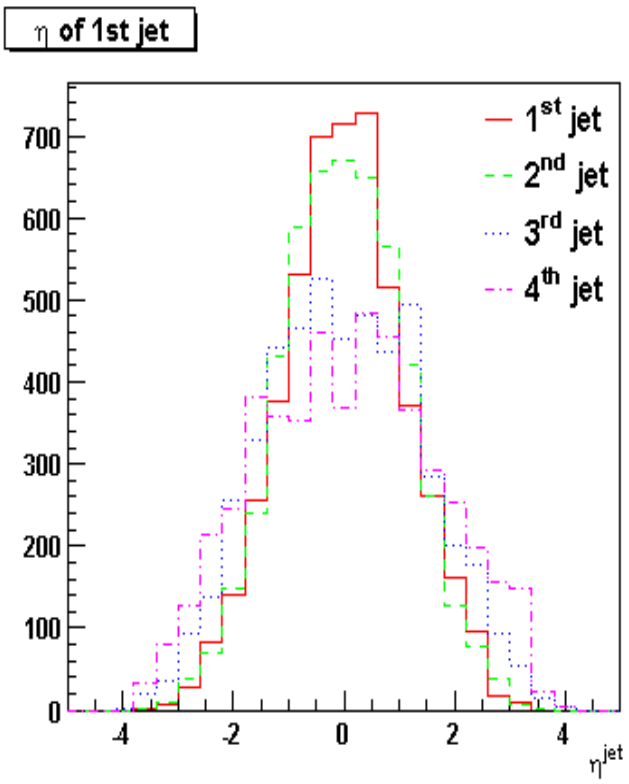
Event Kinematics(5)

After reconstruction

Jets are reconstructed with simple cone algorithm R = 0.5

P_T and η distributions of 4 leading jets

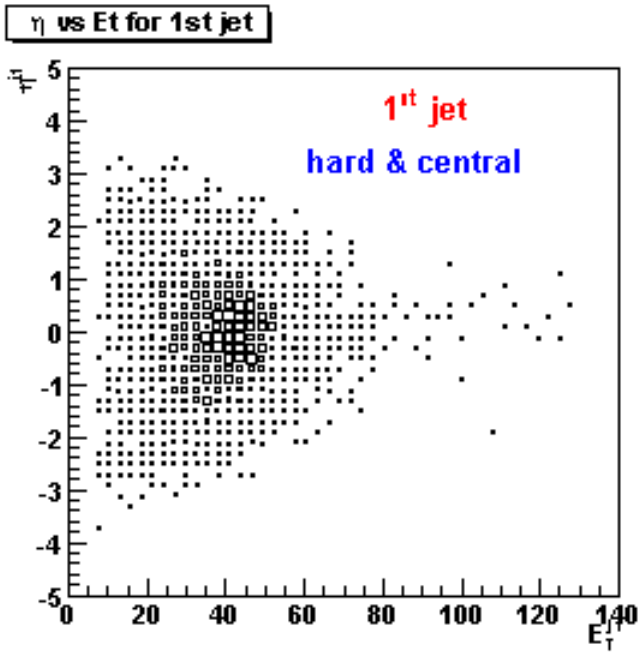


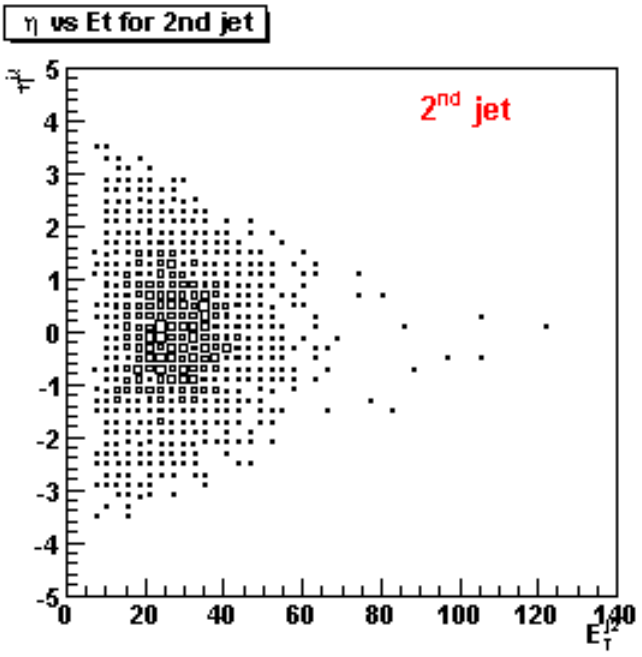


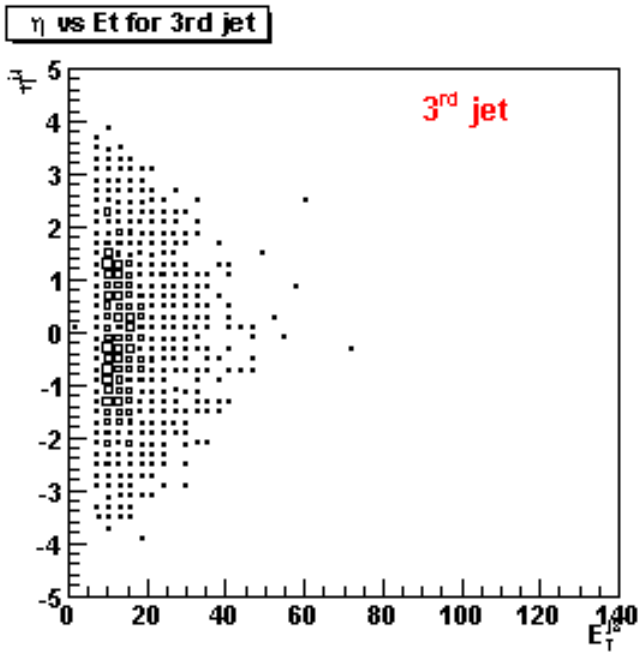
Event Kinematics(6)

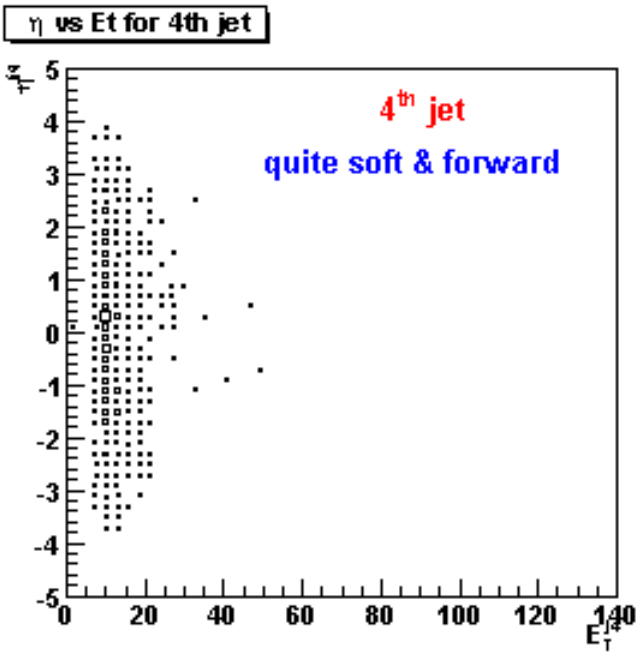
After reconstruction

η vs P_T correlations for 4 leading jets







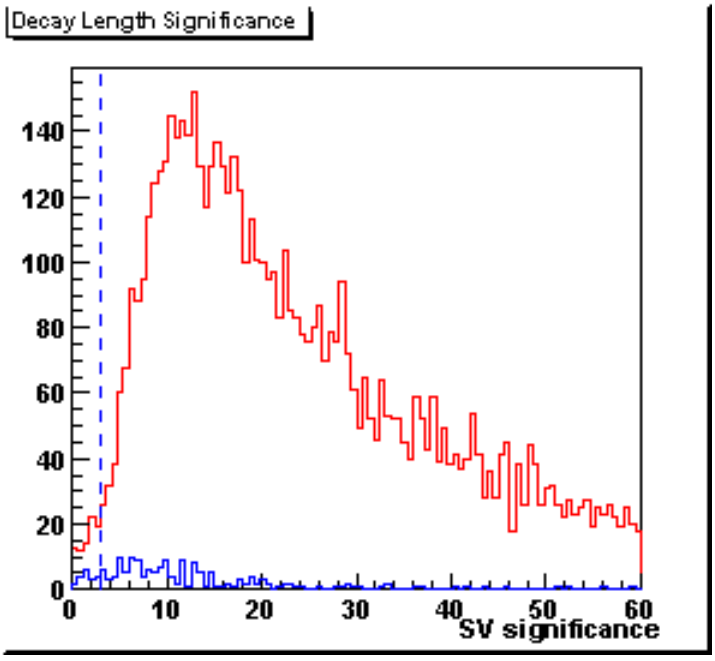


b – jet Tagging(1)

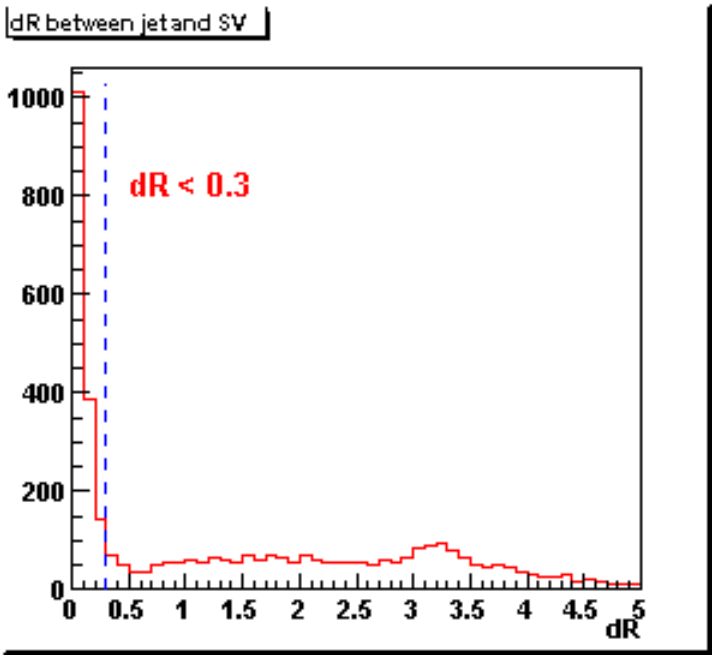
- Secondary vertices are reconstructed using Kalman filter.
- Only those SV are selected for which $L/\sigma > 3$
- Jets are reconstructed with simple cone algorithm R=0.5
  - Jets are SV tagged if $\Delta R(\text{jet, SV}) < 0.3$

b – jet Tagging(2)

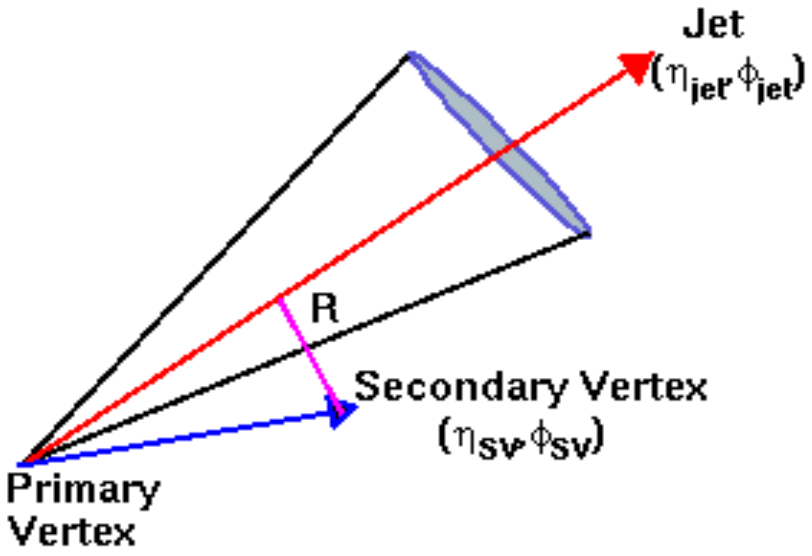
SV significance

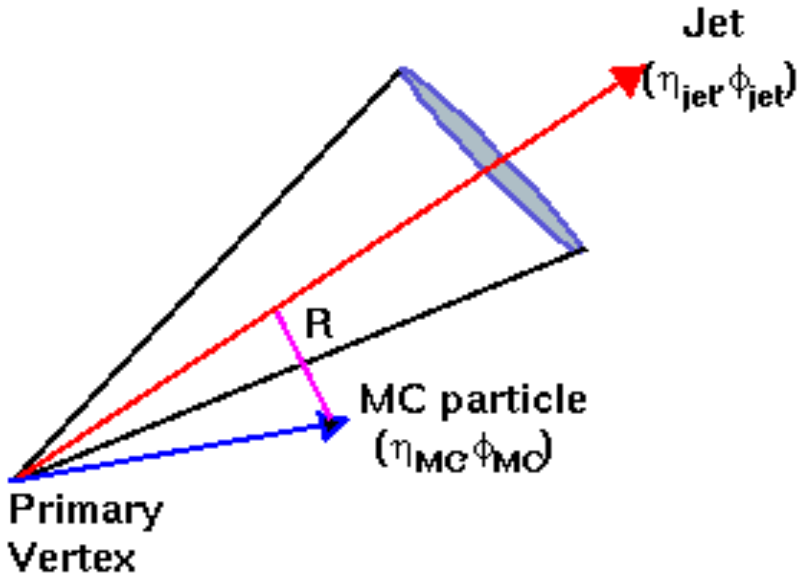


ΔR between jet and SV



Matching

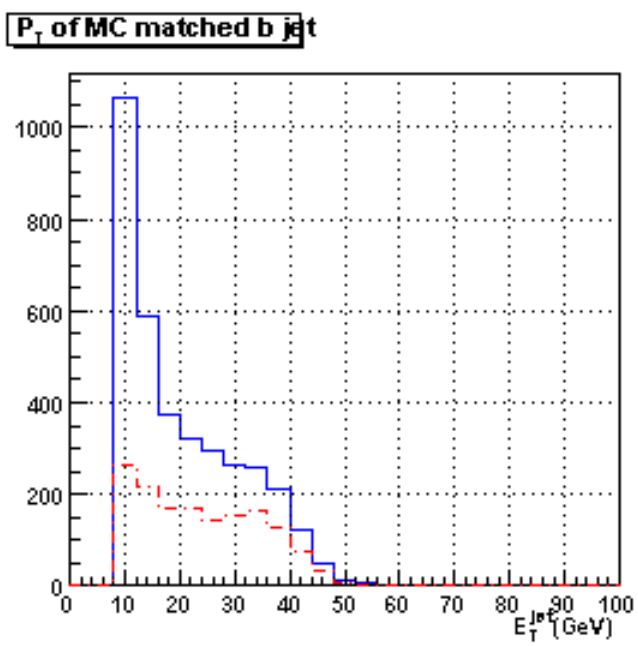

Jet
(η_{jet},ϕ_{jet})
R
Secondary Vertex
(η_{SV},ϕ_{SV})
Primary
Vertex

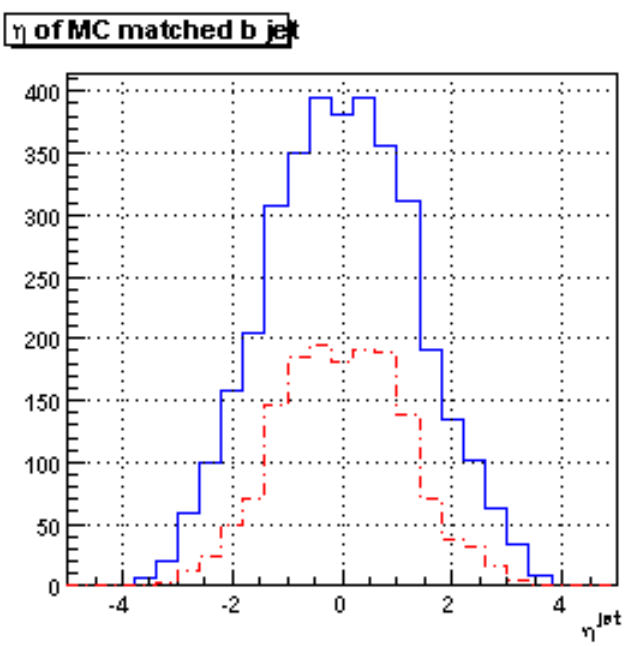

Jet
(η_{jet},ϕ_{jet})
R
MC particle
(η_{MC},ϕ_{MC})
Primary
Vertex

b – jet Tagging(3)

P_T and η distributions for

b-tagged jet and b-jet

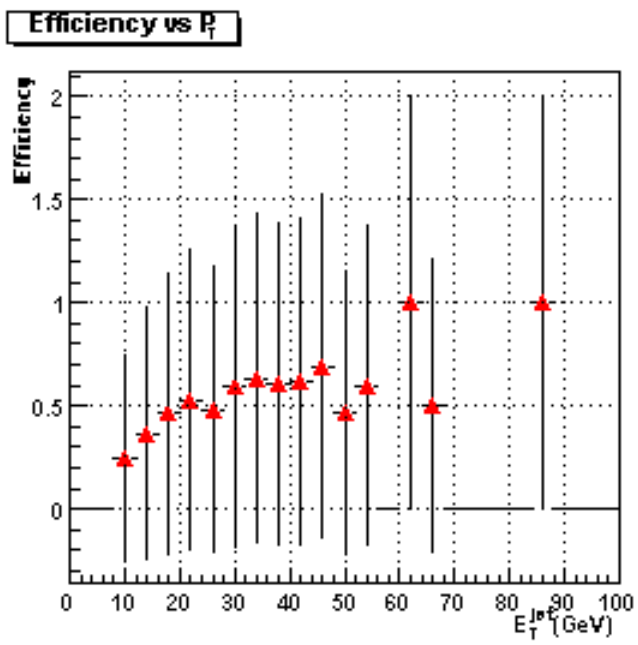


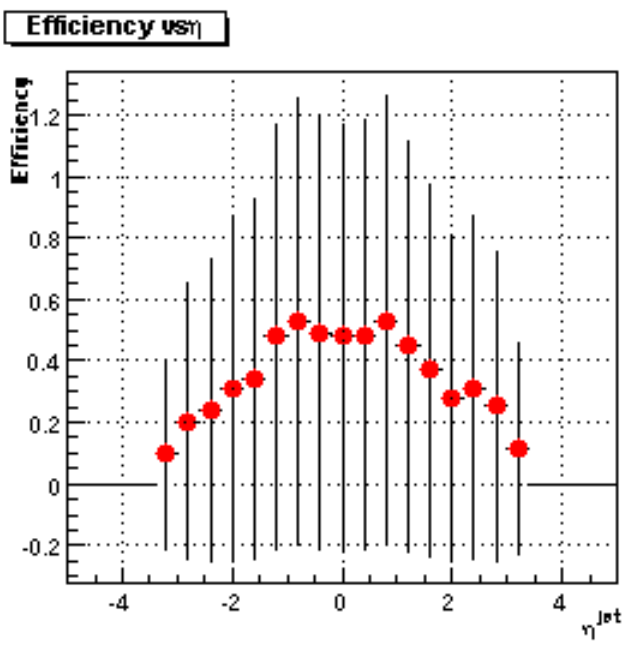


Efficiency = b-tagged jets / all b-jets

b – jet Tagging(4)

P_T and η dependence of tagging efficiency.





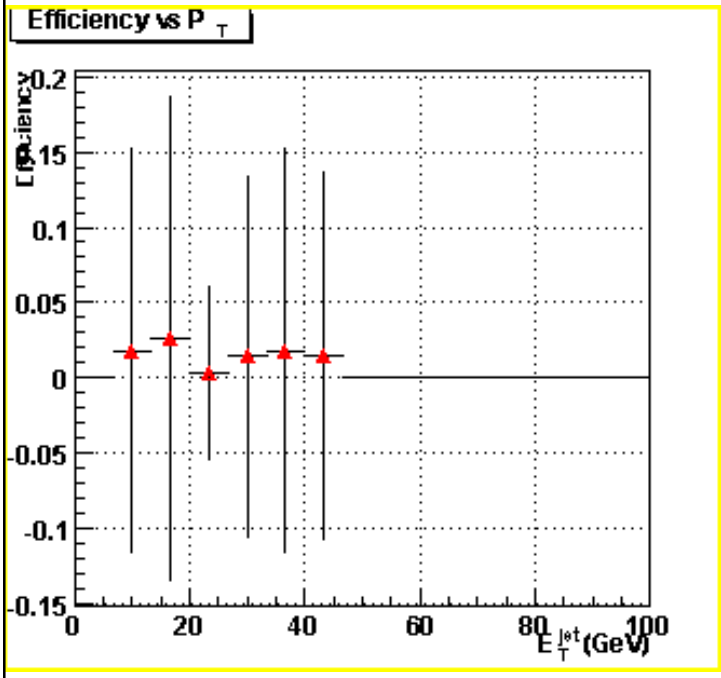
Efficiency is ~50% for P_T >30 GeV and is very poor for |η| > 2

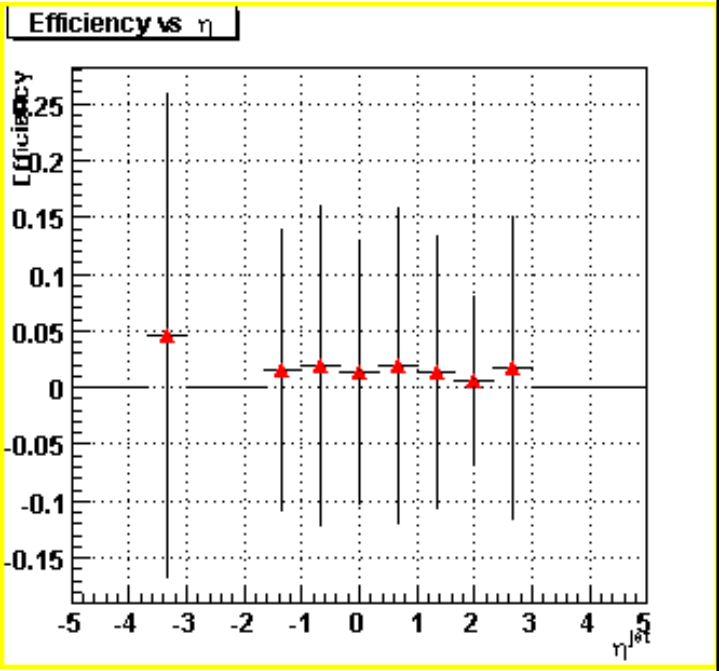
Mis-tag Rate

Used sample ddh(→dd) 5K events

Kinematics are like 4b case

Pass through same analysis chain as 4b's





Conclusions

- bbh production has been looked at with detailed simulations.
- Secondary Vertex b-tagging efficiency and mis-tag rate have been studied.